is placed in the denominator of the second term. The expression is

$$\tau_n = A - B/(n + c)^2.$$

That this is capable of giving results of very considerable accuracy is shown by its application in the case of the spectrum of helium, these results being given in the *Verhandlungen der Naturforschenden Gesellschaft in Basel*, Band xi. Heft 3, a "Separatabdruck" of which paper we have before us. All six series of lines in the spectrum have been computed, and in every case the differences, observed minus calculated, are small. Herr Balmer describes also a method by which the line series can be graphically constructed.

THE "LINCEI" AND EXPERIMENTAL SCIENCE.[1]

IN accepting the invitation to deliver an address on the twenty-first anniversary of the revival of this Academy, when it added social and philological science to mathematics and physical and natural science, I have from the outset not ignored the difficulty of my task, which I have since found even greater than I expected. Nevertheless, a consideration of the work done by the first Lincei, who founded this most ancient of all existing scientific Academies, and a notice of their contribution to the progress of all experimental sciences, particularly biology, appeared to me a subject worthy of your attention.

Federico Cesi, founder of the Lincei, leaving Rome in 1618, handed over to D. Virginio Cesarini, and Giovanni Fabri, Fellows, the mission of giving the ring of the Lincei to Carlo Muti. Cesarini subsequently wrote to Cesi that he had instructed the newly-elected Fellow in the usages and rules of the Academy, and "particularly in the liberty of conscience, love of truth, confession of ignorance, and also, so far as my poor intelligence can, I have not failed to open to him the true founts of human science, not dialectic but real, praising mathematics and natural science as the sole and only principles by which to gain knowledge in this world." The extract, which I have taken word for word, shows clearly the method by which alone the Lincei believed scientific truths could be sought out; and we should have known it more exactly but for the loss of a manuscript, by Cesi, on the "Universalis rationis speculum in quo universalis ars continetur." Still, we do know that at the first meeting, held October 15, 1603, Giovanni Eckio described the operation of the mind, by which it proceeds from facts to conceptions; that is to say, he spoke of induction.

The Lincei were not content with philosophising, but made experiments on subjects pertaining to natural and medical science; and set themselves to observe and calculate the motions of the stars. To this end they provided apparatus and instruments, including the telescope and the microscope, which latter they were the first to use, making known its advantages in the study of botany and zoology. The first print of a microscopic object is that by Francesco Stelluti, representing the honey bee, and placed as frontispiece to the *Apiarium* by Cesi, published in 1625.

The Lincei were also the first who instituted experiments to solve the question of the generation of living objects from putrefaction, an opinion then universally held. We find that Cesi was the first to recognise the animal nature of sponges, corals, and fresh-water polypi; that he maintained there was a gradual transition between the three natural kingdoms, and that he discovered fossil wood. For their method of pursuing science, the Lincei were persecuted from their very first meeting in 1603, and so bitterly, that they were obliged to separate and keep apart for several years. The Lincei had been preceded by Leonardo da Vinci, who held induction to be the only legitimate method in natural science; by Andrea Vesalio, who had overthrown Galen, insisting on the direct study of human anatomy; and by Niccolo Copernico, who subverted the Ptolemaic system, and established the sun as the centre of our planetary system around which the earth and other planets revolve.

On another side, the ground for scientific research had been prepared by the Florentine Platonic Academy, who had substituted Plato for Aristotle, and had grafted platonic idealism on the growing sentiment of Christian art. It was necessary, however, to free science from the spirits of the alchemists, from the idealism of the neoplatonists, from the teleological argument of the scholiasts; in a word, from every trace of transcendency and of finality, so that the human mind, being freed from prejudices and preconceptions, might be enabled, through the study of nature, and by the aid of mathematics, observation, and experience, to seek the real causes of phenomena. This was the work initiated by the Lincei, this was the innovation, deemed bold and dangerous, which gave rise to the new philosophy—Natural Philosophy—which in its turn originated the great scientific movement culminating in a Galileo, a Bacon, and a Descartes.

Galileo lived in the scientific atmosphere of the Lincei (to which Society he was elected in 1615), and he is held to be the founder of the experimental school, proceeding with steady steps in their ways, inventing valuable instruments, and making discoveries of the greatest scientific value. Bacon made no experiments, but gave instead the laws of induction; yet living among such surroundings as those of Elizabeth's court, then swarming with alchemists, notwithstanding his having combated their philosophy and that of the scholiasts with much minuteness, he still believed in spirits, and could not unfetter himself from final causes. Bacon has been accused of not appreciating with exactness the relation between cause and effect, not caring for mathematics, and supposing effects the results of one sole cause, which rarely occurs in nature. Purely inductive methods do not suffice for natural science, for when by them we arrive at one acquired truth, we can from this one deduce others by reasoning, and even rise by mental theories to more general principles. In this sense great credit is due to Descartes, who employed deductive methods, and exhibited the advantages in the study of nature arising from mathematics, as had been already recognised by the Lincei, and used by Copernicus, by Kepler, and, in conjunction with experimental methods, by Galileo.

To demonstrate the importance of the true causes which act on living organisms not solely from their exact value, we might adduce numerous examples taken from the progress made in our own time by medicine, the most practical and beneficent to humanity of all sciences; for if physics and chemistry have by their appliances increased the enjoyments of social life, medicine has succeeded in lightening many of the burdens of suffering humanity. The terror produced by the announcement of a great epidemic, when it was believed to be a chastisement sent from heaven to punish men on earth, ceased from the day when it was found to be the deleterious action of minute living objects, the so-called pathogenic microbes, and when aseptic and antiseptic cure, and the inoculation of attenuated virus and of curative serums were discovered to subdue and destroy the infinite armies of these imperceptible but deadly enemies to mankind, animals, and useful plants. I will not dwell longer on these and other victories of contemporary medicine, my only intention being to treat of science, which does not take account of utility, but is intent on discovering the causes of phenomena. If in practical life we must look to the good of humanity in science, there can be no special ulterior object of any kind. In medicine, however, as in every other science, we distinguish practice, or the application of scientific truths to the benefit of humanity, from science itself. Medicine reaps the benefit of the whole science of life, biology, of which morphology is an essential part, as well as that which seeks the true causes of organic forms in their origin, growth, and involution. Morphology, then, is called upon to solve the problems of organisation; for example, we desire to know why animals and plants leave their present form, in what way species differ or resemble one another, and in what relation they stand to their ancestors. The answer to such queries was at one time easy, but not scientific; when, that is to say, it was believed there was one pre-established type in which individuals were formed and species fixed, the answer was: that the form was what had been created, that consequently species were independent, that their ancestors had for their mission only to bear in their loins germs of such as they had been themselves, created contemporaneously with other matter in determined numbers, and with their form predetermined even to its minutest parts. With this doctrine research flagged, nothing was explained, and from the time of Gassendi (1592-1655), who was the first to formulate it, up to our present century, that is to say, till it was overthrown by the doctrine of evolution, our knowledge of living beings remained stationary. The science of the organisation of living beings, therefore, commenced when the theory of evolution became prevalent.

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[1] Abridged translation of an address delivered before the Reale Accademia dei Lincei, by Signor Todaro.

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Evolution admits that, as a result of real causes, characteristics may vary and be transmitted to descendants; hence, species are established by transformation from a common origin. Hereditary variation and transmission are the two essentials in the conception of species as now understood by zoologists and botanists, who regard them rather as to what they may become than what they are. This new conception of species has brought about an entire revolution in the study of biology, it being now recognised that individual, or, as it is called, ontogenetic development depends on genealogical or philogenetic development, in which the causes of existence must be sought, and the explanation found of the form presented by animals and plants in the actual state. Various theories, which I will briefly note, have been formulated to explain the action of the causes which produce the astonishing phenomena of variability of character and their hereditary transmission. The first of these theories, natural selection, which tried to explain everything, has had its day, and now is only invoked to account for certain secondary characteristics, or those attributed to the adaptations of individual forms. In fact to admit, with Darwin, the selection of properties subservient to their purpose, such as would arise in the struggle for existence, in which the strongest would survive, is the same as introducing a teleological cause into the explanations of nature, where no struggles nor purpose exist, but only phenomena which are in the relation of cause to effect, as had been established by natural philosophy. The principle of improvement from internal causes, propounded by Nägeli, is but the affirmation of a result of which the causes, not only internal but also external, acting and reacting on each other, still remain to be found. Julius Sachs accepts improvement from internal causes, but adds mechanomorphosis produced in plants by mechanical means, such as the action of light and of gravity.

To study the effects of physico-chemical, or mechanical causes in living bodies, Roux has lately formulated his biomechanical theory, which is far more scientific than the old mechanical theory of Descartes. Nevertheless the author does not take into account development, which is the fundamental principle of evolution, and in consequence of which forms and structures cannot all be explained solely by actual causes; since we must not lose sight of the idea that actually existing forms are essentially the product of causes which have operated slowly and successively in time. Roux, wishing to give the explanation of the trabecular structure of the liver, and the multipolar form of the hepatic cells of adult mammals, refers the cause of the orientation of the above-named cells to the action of material exchange, and which, from the bipolar form they take in all glands, have become transformed into multipolar cells in the liver of adult mammals. Hence, he refers also to this cause the transformation into fine network of the nutritive circulation which from tubular has become trabecular. But the case given by Roux leads us to one conclusion only, namely, that the elements, tissues, and organs are so closely correlated, that no alteration can take place in one without necessarily occasioning alteration in the others. But to know how the liver of adult mammals has become trabecular, and its hepatic cells multipolar, it is necessary to investigate the history of its genealogical development, such a transformation being effected by causes which have worked in time.

Can this investigation be made? Surely, by not limiting ourselves to the bare testimony of our senses, but by taking advantage also of induction. Comparing the liver of the adult with the liver of the embryo of the same mammals and with the liver of the other vertebrates, observation shows that in the embryo of mammals the liver is tubular, exactly as it is found in inferior vertebrates, even in the adult stage; hence we have been able to conclude that there was a period when, in the ancestor of the mammals, the liver was tubular through its whole life, and that the trabecular form is a later development. Thus far it is true we have not pointed out precisely what is the cause, or rather what are the causes which have transformed the gland from tubular to trabecular; but can we fill up this hiatus by the study of present causes? In the example under consideration, when we know that the nutritive current runs in one case only in one direction, and in the other in various directions, we cannot yet say that we therefore know the cause or causes of such variations, since we do not know precisely what were the causes, external and internal, which produced the alteration in the material exchange. Only by comparative research of organic forms we find that the trabecular form of the mammals is derived from the tubular form, and we thus come to an important result, thanks to which we can establish the parentage of animals—namely, that in the embryo are registered the genealogical documents of the race of his ancestors; and if we can but read them we shall find them, although more or less modified. Usually the more recent are the more clearly imprinted, while it is difficult to decipher the very old ones; indeed, sometimes these are entirely lost. We have an example in the development of the Molgulidæ and of the Salpæ, which, together with the Ascidians and other forms, constitute the class Tunicata.

The larvæ of the Ascidians pass through two phases of development; in the first, they present the cordate type, which subsequently disappears, being transformed in the second phase into the definite and exact type of the Tunicata. Now, in the Molgulidæ and in the Salpæ the first phase is suppressed; the cordate type is not repeated, and development commences directly from the Tunicata type. Without the Ascidians we should be unable to establish the relationship of the Tunicata with *Amphioxus* and the Vertebrates; and the class Tunicata would have remained where at one time it was placed, between worms and molluscs. Now, thanks to historical and philogenetic research, we know that a high place awaits the Tunicata beside the Cordata and the Vertebrates; and we are led to admit that these three great classes have a common origin, the Protocordatus, which has disappeared, but which we can reconstruct from the characteristics we meet with in these three classes.

The reconstruction of extinct organisms, which we are able to effect by the study of morphology, demonstrates the highest function of this science; the veracity of such reconstructions has been sometimes confirmed by successive zoological and palæontological discoveries. From the fundamental characteristics we meet with in the embryos of Ascidians, *Amphioxus* and the Vertebrata, we can affirm with certainty that the common progenitor of the Tunicata, the Cordata and the Vertebrata, had the form of a fish; possessed an intestine divided into an anterior part chiefly respiratory, and a posterior part digestive; had a body divided into segments, a spinal cord, and a nervous dorsal tube decurrent from its anterior to its posterior extremity, an arterial longitudinal dorsal vessel and a venous ventral one. Here, then, is one of the important results achieved by science through the study of organic forms.

Nor have results of lesser importance been obtained by researches on heredity. Progressing by experiment; aided by optical appliances, which in our day have made astounding progress, and by which the microscope has been raised to a high pitch of perfection; furnished with the most precise and delicate methods of modern histological technique, by which every living element can be detected in the various phases of its activity; we have succeeded in discovering an important part of the secrets with which nature has surrounded the generation of living beings, secrets which naturalists of time not long past had declared impenetrable.

Guided by experimental methods, we may hope that science will be able ere long to solve complex and important questions relating to the organisation of living bodies; we seek not the nature of things, which is impossible for us to learn, but the true reason of phenomena, remembering what the Lincei had affirmed from their very first institution—liberty of conscience, love of truth, confession of ignorance.

THE NATURAL IMMUNITY OF VENOMOUS SNAKES

IN a previous article (NATURE, October 24, 1895, p. 621) the "Serum Treatment of Snake-bite" was briefly discussed by the writer of this note; and Calmette's and Fraser's researches are now so well known, that it is not necessary to give a summary of them. One or two points, however, must again be alluded to, because recently Dr. D. Cunningham, of Calcutta,[1] has carried on some important experiments which throw fresh light on the matter, and which also supply answers to some of the questions raised by the writer in the above-mentioned article.

The most surprising conclusion of Calmette and Fraser was that the serum of an animal immunised against cobra poison will protect not only against this poison, but also against the poisons of other snakes. It might be thought that this is an argument against Behring's law that the action of immunising serum is

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[1] "Scientific Memoirs by Medical Officers of the Army of India," 1895, ix. p. 1-30.

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